SPICE Conventions

**A summary of many "standards," lingo
and common usage within SPICE**

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Navigation and Ancillary Information Facility

SPICE

- **The name of this ancillary information system**

NAIF

- **The name of the team of people at JPL who lead development of the SPICE system.**
- **Also the name of the ancillary data node of NASA's Planetary Data System (PDS).**

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SPICE Toolkit **NAIF Toolkit** **The Toolkit**	• **Names that refer to the principal collection of software produced by JPL's NAIF Team as part of the SPICE information system. May include mission- or domain-specific augmentations.**
Generic Toolkit	• **A Toolkit that contains no mission-specific or enterprise-specific augmentations. This is what is available from NAIF's website.**
SPICELIB	• **The principal user library found within Fortran versions of the Toolkit.**
CSPICE	• **The principal user library found within C versions of the Toolkit. Also used to refer to the entire C Toolkit.**
Icy	• **An IDL interface to CSPICE**
Mice	• **A MATLAB interface to CSPICE**

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- ## Text kernel

  – Any kernel type consisting entirely of ASCII information, with each line terminated using the local operating system convention (CR, LF, CR+LF)

  – Text kernel types are FK, IK, text PcK, LSK, SCLK, MK ("Furnsh")

  – Any and all text kernels could be combined in a single file.

    » But this is certainly not recommended!

- ## Binary kernel

  – Any kernel type using binary file format

  – Binary types are SPK, binary PcK, CK, DBK and DSK

  – Different binary kernel types can not be combined together in a single file

- ## Transfer format kernel

  – A hexadecimal (ASCII) version of a binary kernel, used ONLY for porting a binary kernel between incompatible computers.

  – Not as important as it was prior to the addition of the so-called "binary kernel run-time translation" capability provided in Toolkit N0052 (1/2002).

    » But still has a role in making native binary kernels required for some operations.

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- ## Database Kernel (DBK)
  - A SPICE kernel that, in conjunction with Toolkit DBK software, provides a self-contained SQL-like database capability.

- ## "Command file"
  - Many SPICE application and utility programs either require, or optionally accept, an input file containing program directives and sometimes input data. Unfortunately NAIF has not used a consistent approach for referring to such files. The following names have been used:
    - » Setup file, preferences file, command file, specifications file, definitions file

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- ## Deprecated software
  - Code that, while still useable, has been superseded with a newer and presumably better version
  - We encourage you to not use deprecated SPICE software
    - » (But, for your convenience, we won't remove it from the Toolkit packages) 🙂

- ## Toolkit version naming
  - "Nxxxx"   e.g. N0061 is version 61
    - » Often shortened to just Nxx (e.g. N61)

- ## "Satellite" is used to refer only to a natural satellite, never to a spacecraft.

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Names used synonymously

- **Kernel, SPICE file, SPICE kernel, SPICE kernel file**
- **Metadata, comments**
- **Time, Epoch**
- **Encoded SCLK, ticks***
- **Frame, Reference Frame****
- **Ephemeris, trajectory**
- **Rectangular coordinates, Cartesian coordinates****
- **Geodetic, Planetodetic (coordinate system)**
- **Ephemeris time (ET), Barycentric Dynamical Time (TDB)**
- **Attitude and orientation**
- **International Celestial Reference Frame (ICRF) and Earth Mean Equator and Equinox of 2000 (J2000) reference frame**
- **Meta-kernel and Furnsh kernel**
- **Module, routine, subroutine, procedure, and function (in C and MATLAB)**
- **"Body", "solar system object" and "ephemeris object"**

* Encoded SCLK <u>always</u> refers to absolute time; "ticks" is used to refer to both durations and absolute times.

** Outside of SPICE the term "coordinate system" is often used synonymously with "frame" or "reference frame." We prefer to use "coordinate system" in the sense of describing how coordinates are measured (e.g. cylindrical coordinate system, Cartesian coordinate system, polar coordinate system, etc), and to use "frame" in the sense of a set of three orthogonal vectors.

Kernel File Names

- **SPICE <u>imposes</u> some restrictions on kernel file names**
  - **No white space allowed within a name**
  - **Maximum length of a name (including any path specifications) is 255 characters**
    - » **See the tutorial "Intro_to_kernels" for limitations on file name specifications contained within meta kernels ("furnsh kernels")**
- **NAIF <u>suggests</u> names conform to the PDS standard: "27.3"**
  - **<1 to 27 alphanumeric characters>.<1 to 3 chars>**
- **Common usage within NAIF for SPICE kernel file name extensions is listed on the next page, with the following general style used:**
  - t*   text format   (e.g. leapseconds.tls)
  - b*   binary format   (e.g. de405.bsp)
  - x*   transfer format   (e.g. de405.xsp)

Common SPICE Kernel File Name Extensions

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SPK:

.bsp   binary SPK file

.xsp   transfer format SPK file

PcK:

.tpc   text PcK file
(This is the most common type PcK)

.bpc   binary PcK file
       (few instances of this)

.xpc   transfer format PcK file
       (few instances of this)

IK:

.ti   text IK file

FK:

.tf   text FK file

LSK:

.tls   text LSK file

CK:

.bc   binary CK file

.xc   transfer format CK file

SCLK:

.tsc   text SCLK file

MK:

.tm   text meta-kernel file ("FURNSH kernel")

DSK:

.bds   binary DSK file

EK Family (ESP, ESQ, ENB)

ESP:

.tep   text Science Plan EK file
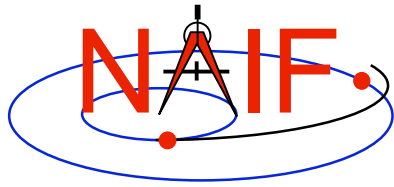
ESQ:

.bes   binary Sequence Component EK file

.xes   transfer format Sequence Component EK file

ENB:

n/a   (www interface)

These are suggestions, not requirements

SPICE Conventions

Common Document Name Extensions

- **These extensions are used for plain ASCII documents included with each Toolkit delivery**

.ug	User's Guide
.req	"Required Reading" reference document
.txt	Used for a few miscellaneous documents
.idx	Used only for the permuted index document

- **All HTML documents included in the Toolkit have extension .html**

- **Alternate formats of some of the Toolkit documents are available from the NAIF anonymous ftp server**

.pdf	PDF documents

Public and Private Modules

- **All Toolkits include public and private modules**

- **Public modules are available for your use**
  - Names of public APIs are different in the four SPICE library implementations. For example, the top level SPK reader SPKEZR has the following names
    - » in SPICELIB (FORTRAN)   **SPKEZR**
    - » In CSPICE (C)   **spkezr_c**
    - » ICY (IDL)   **cspice_spkezr**
    - » Mice (MATLAB)   **cspice_spkezr** and **spkezr_mice**
  - The API Reference Guide included in the Toolkit HMTL documentation provides the complete list of all public SPICE APIs available in a specific implementation of the Toolkit

- **Private modules are for NAIF staff use only**
  - **Names of private modules start with "ZZ"**
  - **They are present in the Toolkit only to support operations of "public" modules**
  - **Private APIs are not listed in the API Reference Guide but can be seen in the source code directories for SPICELIB, CSPICE, and Mice**
  - **Do not use "private" modules in your code – they may change**
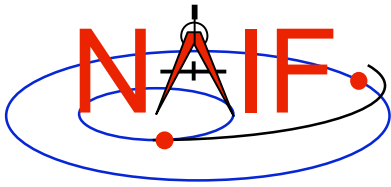
Reference Frame and Coordinate System Conventions

- **All reference frames used within SPICE are right handed systems**
  - X cross Y = Z

- **In planetocentric reference frames the +Z axis (+90 LAT) always points to the north side of the invariable plane (the plane whose normal vector is the angular momentum vector of the solar system)**
  - Planetocentric longitude increases positively eastward
  - Planetocentric latitude increases positively northward

- **In planetographic reference frames:**
  - Planetographic longitude is defined such that the sub-observer longitude increases with time as seen by a distant, fixed observer in an inertial reference frame
    - » The earth, moon and sun are exceptions; planetographic longitude is positive east by default
  - Planetographic latitude increases positively northward

Quaternions

- **The SPICE system uses quaternions in C-kernels**

- **There are different "styles" of quaternions used in science and engineering applications. Styles are characterized by**
  - **The order of the quaternion elements**
  - **The quaternion multiplication formula**
  - **The convention for associating quaternions with rotation matrices**

- **Two of the commonly used styles are**
  - **"SPICE"**
    - » **Used by Sir William Rowan Hamilton (discoverer of quaternions)**
    - » **Used in math and physics textbooks**
  - **"Engineering" or "MSOP"**
    - » **Widely used in JPL ACS/AACS and other aerospace applications**

- **The relationship between SPICE and MSOP quaternions:**
  - **Let M be a rotation matrix such that for any vector v, M*v is the result of rotating v by Θ radians in the counterclockwise direction about unit vector A. Then the quaternions representing M are:**
    - » **SPICE: (+/-) (cos(Θ/2),   sin(Θ/2)A(1),   sin(Θ/2)A(2), sin(Θ/2)A(3))**
    - » **MSOP: (+/-) (-sin(Θ/2)A(1), -sin(Θ/2)A(2), -sin(Θ/2)A(3), cos(Θ/2))**

- **Details about SPICE quaternions are found in:**
  - **Rotations Required Reading document**
  - **NAIF white paper on quaternions:** ftp://naif.jpl.nasa.gov/pub/naif/misc/Quaternion_White_Paper/
  - **SPICE quaternion conversion routines: M2Q, Q2M**
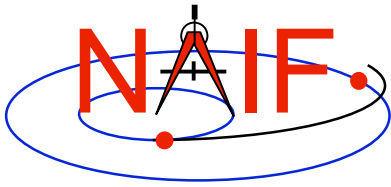
Names and IDs

- **Many items within SPICE have assigned names (text strings) and IDs (integer numbers)**

- **The NAIF/SPICE rules, standards, practices and exceptions regarding these names and IDs are discussed in a separate tutorial ("Names and IDs")**